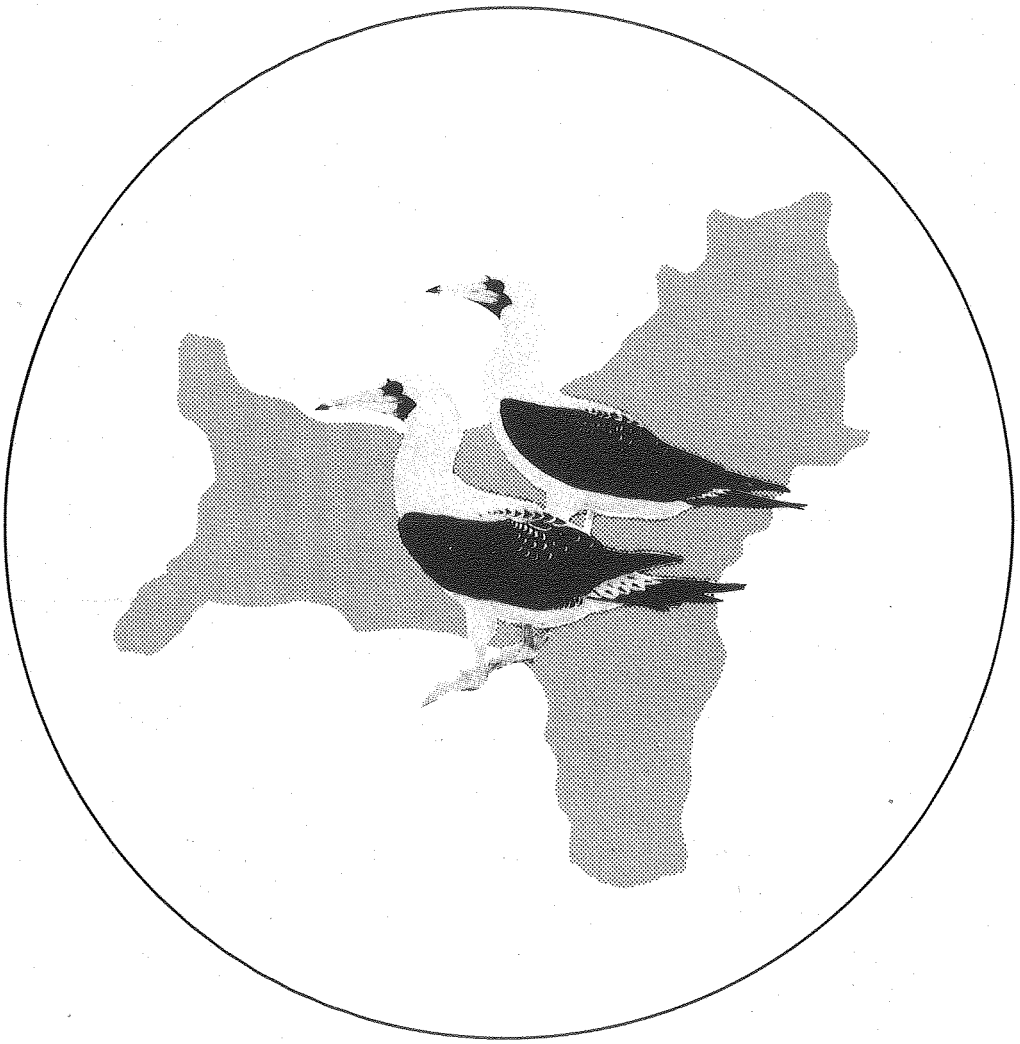
Appraisal and implications of a survey (1979-80) of Abbott's Booby on Christmas Island



Emeritus Professor J.D.Ovington

Professor J.M.Cullen

Dr. J.B.Nelson

23 January 1981

APPRAISAL AND IMPLICATIONS OF A SURVEY (1979-80)

OF

ABBOTT'S BOOBY ON CHRISTMAS ISLAND

by

Emeritus Professor J. D. Ovington
Professor J. M. Cullen
Dr. J. B. Nelson

23 January 1981

"It will not be much use if, after spending so much time and effort cleaning up the environment and limiting the population, we wake up to find that, in the meantime, whole lists of creatures and plants have disappeared from the face of the earth."

H.R.H. Prince Philip, Duke of Edinburgh

C O N T E N T S

BACKGROUND

1. Introduction

Phosphate mining is the only industry on Christmas Island, an external territory of Australia. Clearing of the jungle prior to mining results in the destruction of nesting sites of Abbott's Bobby, an endangered bird species whose world breeding distribution is limited to the Island. Because of concern to save Abbott's Booby, a detailed survey of its distribution and status on Christmas Island was carried out in 1979 and 1980 by D. A. Powell, the Conservation Officer of the British Phosphate Commissioners and J. Tranter, the Assistant Conservator. Whilst the survey was underway and the results evaluated a moratorium on further clearing was instituted in certain central and western areas of the Island known to be important breeding areas for Abbott's Booby.

The principal objectives of the survey were stated as:

(a) to prepare a detailed and accurate map showing the distribution of nesting Abbott's Boobies over the entire Island for comparison with Dr. Nelson's 1966/67 plotting of nestsites; particular emphasis to be placed on the areas of Fields 22A, 22B, 24 and MH31; and

(b) to monitor regularly the numbers of incoming birds as a measure of the size and seasonal fluctuations in the part of the population which visits Christmas Island (some birds may remain at sea).

The Director of National Parks and Wildlife was required to convene a three member expert panel to appraise the results of

the survey for presentation to the Christmas Island Phosphate Commission and the British Phosphate Commissioners, the Departments of Administrative Services and Home Affairs and Environment, and the Australian National Parks and Wildlife Service. The results of the survey (Powell and Tranter 1981), were received on 15 January 1981. In this report by the panel information on the environment, history and biological resources of Christmas Island is given before commenting on the survey. Members of the panel were:

Professor J. D. Ovington (Convenor),
Director of National Parks and Wildlife,
Australian National Parks and Wildlife Service

Professor J. M. Cullen,
Department of Zoology,
Monash University, Melbourne

Dr. J. B. Nelson,
Department of Zoology,
University of Aberdeen, United Kingdom

Dr. Nelson was unable to come to Australia. However, he received a copy of the survey results and his participation in the survey appraisal was by telephone, telex and written communication. The panel was assisted by M. Hill and J. Forshaw officers of the Australian National Parks and Wildlife Service and benefitted by discussions with Mr. D. A. Powell during a two day visit to Canberra. J. Tranter worked hard for long hours on Christmas Island to provide computer printouts of site distribution and other information requested by the panel. W. Pearson and G. Drake of the Australian National Parks and Wildlife Service, prepared the figures.

This report by the panel is based largely on data supplied by officers of the British Phosphate Commissioners. Their co-operation is greatly appreciated.

2. Physical Geography

Christmas Island is situated in the Indian Ocean at $10^{o}28'S$, $105^{o}38'E$, and is approximately 133 sq. km in area (Figure 1).

The Island is an isolated seamount of volcanic origin with a discontinuous capping of limestone. It rises from ocean depths of some 4500m and reaches a maximum altitude of 357m above sea level at Murray Hill. There are a number of minor hills and distinct fault lines.

From the central upper plateau the land descends to the sea in a series of steep slopes alternating with terraces. A cliff of 70 to 100m drops to a shore terrace, terminating in a sea cliff from 3 to 50m high. The sea cliff is continuous round the Island except for a few places, the most notable being Flying Fish Cove where the main settlement is located and which is the only known anchorage.

A layer of superficial soils derived from the weathering of volcanic lavas and tuffs covers portions of the upper plateau and the terraces. The soil, together with underlying coral reef detritus has been phosphated by decomposition of avian guano over the centuries as the Island rose relative to sea level. Considerable depths of phosphate material overlie some limestone areas. This phosphate is the basis of the mining industry.

Christmas Island is subject to the influence of the northwest monsoon from about November to April and of the southeast trade winds for the remainder of the year. Whilst there are no records of cyclones crossing the Island, cyclones during the monsoon period pass nearby and subject the Island to strong winds. Temperatures range from about 18 to $30^{o}C$, and the annual rainfall is normally between 2000 and 2500mm, the bulk of

precipitation falling in the monsoon season. The different elevations, the steep cliffs and the weather pattern can produce marked differences between the local climates of places on the Island.

3. History of Discovery and Settlement

The first recorded sighting of the Island was by William Dampier in 1615. On Christmas Day 1643 the Island was named by Captain William Mynors, but the first recorded landing was not until 1688 during a visit by Cygnet a British buccaneer ship. There is no further recorded interest in the uninhabited island until 1860 - 1880 when periodic visits were made by members of the Clunies-Ross family of the Cocos (Keeling) Islands to cut timber for boatbuilding.

In 1887 the first phosphate specimens were taken from the Island. Christmas Island was formally annexed for Britain in 1888. In 1891, John Murray and George Clunies-Ross were granted a joint 99 year lease to extract phosphate and cut timbers, but in 1897 this lease was transferred to the Christmas Island Phosphate Company, with Murray as Chairman and shares divided between the Murray and Clunies-Ross families. In 1900 Christmas Island was incorporated in the Straits Settlements and in 1942-43 was occupied by the Japanese.

In 1948 the Christmas Island Phosphate Company sold its undertakings and assets to the Australian and New Zealand Governments. In the following year the Christmas Island Phosphate Commission was established under the Christmas Island Agreement Act 1949, with Commissioners being appointed by both Governments. On 1 January 1958 the Island became a separate British Crown Colony, and on 1 October of the same year the administration was transferred to Australia. Christmas Island became an Australian Territory under the Christmas Island Act

1958, though formal involvement of the New Zealand Government in the affairs and operations of the Christmas Island Phosphate Commission was maintained.

At 30 September 1980 the estimated population of 3245 included persons of Chinese, Malay, European and Australian origins. Some have lived on the Island for all, or most, of their lives. Others are contract workers.

THE PHOSPHATE INDUSTRY

1. Legislative History

Under Article 3 of the Christmas Island Agreement Act 1958-73 the Christmas Island Phosphate Commission was granted "full licence and authority to cut timber and to get all phosphates and other minerals in, on and from Christmas Island and all powers necessary or proper for the enjoyment of that licence". In return the Commission was obliged to ensure that as far as practicable phosphate was supplied at the lowest possible cost to Australia and New Zealand (Article 5). Under Article 12 Australia must "consult with the Government of New Zealand in the exercise of its administrative authority over Christmas Island in any matters.....which materially affect the working of the said property by the Commission". The New Zealand Government has been consulted about the implementation of conservation measures affecting the mining and supply of low-cost phosphate.

Under Article 4 of the Christmas Island Agreement Act 1958-73 the British Phosphate Commissioners serve as managing agents for the Christmas Island Phosphate Commission. All mining operations and associated activities are carried out under the Commissioners.

2. Phosphate Production

To date phosphate mining and the related support services have formed the basis of the only industry on the Island. Mining supplies apatite ore for conversion into superphosphate fertilizer in Australia and New Zealand, while a dust by-product is exported to South East Asia as a direct application fertilizer.

On Christmas Island phosphate rock occurs with varying levels of impurities, so there is differentiation of A grade, B grade and C grade deposits, grade A being the most valuable and grade C the least. Current practice is to supply to Australia and New Zealand 77% (Bone Phosphate of Lime) rock comprising A grade with a mixture of some washed B grade rock. This blending of grades necessitates simultaneous mining in different parts of the Island with the various grades of ore being stockpiled for mixing. Because of stockpiling there is some flexibility in mining operations, and this has been helpful in the implementation of moratoria or other constraints on jungle clearing.

Prior to the clearing of an area for mining the Conservation Officer of the British Phosphate Commissioners identifies active nesting sites and these are left undisturbed until the young birds have left the nests. Subsequently the sites are cleared and the phosphate mined. After mining, natural revegetation is slow because of the unfavourable site conditions but in recent years an attempt has been made to establish a vegetation cover in a few mined areas by returning soil and planting trees.

The Australian Government has accepted some recommendations of the recent Commission of Inquiry into the viability of the Christmas Island Phosphate Industry (Sweetland, 1980). One recommendation is that the Christmas Island Phosphate Commission be reconstituted in consultation with the New Zealand

Government. Another recommendation is that the agreement of the Governments of the United Kingdom and New Zealand be sought to terminate the appointment of the British Phosphate Commissioners as managing agents for the Commission. In the event of this recommendation being implemented it is thought an Australian authority might be set up to mine phosphate on the Island, although its structure and organisation would have to be finalised.

Whilst the Commission of Inquiry found that, subject to certain qualifications, the industry is and can continue to be economically viable, it also recommended that the reafforestation program on the Island should be expanded, with greater use being made of back-filling in mined areas, and that bird populations should be monitored as accurately as possible so that any signs of significant decline can be detected and appropriate action taken.

The reserves of phosphate on the Island are being exhausted progressively and, according to some estimates, under present conditions mining can only continue for less than eight years. A reduction in phosphate production and greater use of low grade ores could extend the period of mining.

BIOLOGICAL RESOURCES OF CHRISTMAS ISLAND

1. Island Ecosystems

In common with all oceanic islands, Christmas Island has a distinct fauna and flora. Because of the distance from any landmass, there is notable endemism in the plants and animals of the Island, the result of evolution in isolation. The Island ecosystems are of major scientific importance because of the unusual assemblages of plants and animals they contain and the implications of this to the functional processes of the ecosystems.

2. Fauna and Flora

As with most small ocean islands, the flora of Christmas Island is relatively poor floristically. There are two hundred species of flowering plants, thirty of these being endemic. Although not rich in plant species, the Island is probably unique in that it possesses an extraordinarily well developed set of unusual structural vegetation types. The plateau rainforest and the more diverse terrace vegetation are the two major types, but within these there are distinct subtypes of great interest, e.g. an inland relict community of mangroves Bruguiera gymnorrhiza raised above sea level and a remnant littoral forest of Heritiera littoralis.

A remarkable feature of the fauna of Christmas Island is the preponderance of crabs, the most abundant of which is the endemic Red Crab Gecarcoidea natalis. The presence of thirteen species of crabs, many of which are large in size, their general abundance and their role in the breakdown of organic matter are unusual for such a small oceanic island.

The reptile fauna comprises eight terrestrial species and an undetermined number of marine species. The terrestrial species are three skinks, two of which are endemic; two blind snakes, one being endemic; and three geckos, including two that are endemic. The most vulnerable reptile species is the rainforest gecko Lepidodactylus listeri. Few data are available for the endangered Green Turtle Chelonia mydas and Hawksbill Turtle Eretmochelys imbricata, which nest on some of the small beaches. Virtually nothing is known of the sea snakes inhabiting the fringing reefs.

The mammal fauna is depauperate. The Fruit Bat Pteropus melanotus is plentiful, and an insectivorous bat Pipistrellus murrayi is also present. Possibly more than one species of insectivorous bat occurs on the Island, but further

studies are needed to determine this and to assess the taxonomic status of P. murrayi. Formerly there were two species of endemic rats, Rattus macleari and R. nativitatis, and a species of shrew Crocidura trichura, but all three are now believed to be extinct.

Christmas Island has been described as one of the world's great seabird islands. The visual impact of large flocks of birds circling overhead is a prominent feature of the Island. Being situated in an ocean with few islands, Christmas Island provides a focal point for seabirds of the Indian Ocean, with boobies, frigatebirds and noddies making up the bulk of the nesting population. There are nine species of breeding seabirds, and of these two are endemic and another is represented by a very distinct subspecies. The two endemic species are Abbott's Booby Sula abbotti, and Christmas Island Frigatebird Fregata andrewsi. The endemic subspecies is the Golden Bosunbird or Tropicbird Phaethon lepturus fulvus.

As would be expected on an island so distant from the nearest landmass, the landbirds exhibit quite a high degree of endemism; there are two endemic species - the Christmas Island Imperial Pigeon Ducula whartoni and the Christmas Island Silvereye Zosterops natalis. Another five species are represented by endemic subspecies.

NATURE CONSERVATION

1. Impact of People

Christmas Island never had an indigenous human population. Whilst it was visited at times by people harvesting seabirds for food, these visits appear to have been spasmodic and confined to the accessible margins of the Island. After settlement much of the Island remained relatively inaccessible until finally opened up by prospecting and drilling to prove

phosphate fields. Consequently, there was little direct human pressure on the fauna of the Island.

Subsequently certain species, particularly the Imperial Pigeon, were exploited quite extensively as access improved. The native rats and shrews were abundant when the Island was first settled, but by 1908 all three species had disappeared. This has been associated with the introduction of the Ship or Black Rat Rattus rattus which is now well established.

With settlement and mining activities have come the introduction of a number of plants, some of which pose a threat to the native vegetation. When weed species, particularly the Japanese cherry Muntingia calabura and the "acacia" Leucaena sp. invade a cleared area, such as an access road or a mined-out field, succession by indigenous tree species is inhibited. The sensitive weed Mimosa invisa is present at South Point, and many access roads are choked with Urena and Sida spp. It is virtually impossible to eradicate these weed species once they become established.

2. Representations

The threatened status of the endemic birds, particularly Abbott's Booby Sula abbotti, has been the focus of international and national concern. It is ironical that the survival of Abbott's Booby is threatened by the value placed by people on the excreta of its avian predecessors.

Abbott's Booby, the Christmas Island Frigatebird and the Christmas Island Hawk Owl, and the two marine turtles are included in Appendix I to the Convention on International Trade in Endangered Species of Wild Fauna and Flora. Species of Christmas Island birds are covered by provisions of the Agreement Between the Government of Australia and the Government of Japan

for the Protection of Migratory Birds and Birds in Danger of Extinction and Their Environment.

There have been strong international representations in support of nature conservation on Christmas Island. At its XVII World Conference in 1978, the International Council for Bird Preservation adopted the following resolution:

> "Believing that commercial pressures for clearance of forest on Christmas Island, Indian Ocean, threatens remaining habitats of several unique endangered bird species;
>
> In view of the uncertain situation now existing and the resultant threat to a number of the endangered birds;
>
> URGES the New Zealand and Australian Governments to enforce preservation of these habitats."

The following resolution was adopted by the International Union for the Conservation of Nature and Natural Resources (IUCN) at its General Assembly in 1978:

> "RECOGNISING the need to conserve original and representative island communities of high conservation value,
>
> RECOGNISING FURTHER the absolute necessity of conserving sufficient critical habitat to enable the continued existence of all species,
>
> CONSIDERING that Christmas Island in the Indian Ocean is the only known breeding site of Abbott's Booby Sula abbotti, and that phosphate mining continues to destroy that breeding habitat.

This General Assembly:

> STRONGLY RECOMMENDS the Government of Australia to establish a national park and nature reserve on Christmas Island sufficient to ensure adequate protection to the Island's fauna, flora and the ecosystems in which they have evolved.
>
> URGES the Governments of Australia and New Zealand and the British Phosphate Commission to take all steps necessary to ensure that the phosphate mining does not further destroy the habitat of Abbott's Booby.
>
> URGES FURTHER that similar control be exercised to ensure that clearing of forested areas does not jeopardize the survival of other endemic faunal and flora taxa."

In response to this resolution, the British Phosphate Commissioners advised IUCN by letter dated 16 July 1979 that all interested parties had agreed to the establishment of a national park on Christmas Island and that the Government Conservator and Commission Conservation Officer were taking necessary steps to ensure protection of Abbott's Booby and other local fauna and flora. In a reply dated 25 October 1979, IUCN expressed appreciation of the progress being made in the establishment of the national park and the support being given by the Commissioners and the Governments of Australia and New Zealand.

On 26 May 1980, His Royal Highness the Duke of Edinburgh wrote to the Prime Minister of Australia advising that International conservation organisations sought a suspension of clearing in all central and western areas until the 1979-80 survey of Abbott's Booby had been completed.

3. Conservation Achievements

With increasing recognition of the conservation significance of Christmas Island progress has been made in nature conservation.

In 1974, the British Phosphate Commissioners appointed from their staff the first resident Conservation Officer, D. A. Powell. He is employed full-time on conservation projects, including the operation of the plant nursery and reafforestation of mined areas.

In 1973, a subcommittee of the House of Representatives Standing Committee on Environment and Conservation examined the effects of mining and other activities on the flora and fauna of Christmas Island. The Standing Committee (1974) recommended inter alia that areas be reserved for conservation purposes and that a Government Conservator be appointed. Subsequently, in 1975 the Island was visited by an Environmental Reconnaissance Team of Australian and New Zealand scientists, and this team endorsed the sub-committee's recommendations.

A Government Conservator was appointed to Christmas Island in 1977, and on 21 February 1980 the Christmas Island National Park was proclaimed by the Governor-General under the National Parks and Wildlife Conservation Act 1975.

Covering approximately 1600ha on the southwestern corner of the Island, the national park contains only a small area with phosphate deposits, is largely undisturbed and remote from settlements (Figure 1). The national park is of considerable conservation significance and includes superb shore terraces with coastal cliff escarpments, the Island's only waterfall and a unique rainforest, and affords protection to some known nesting sites of Abbott's Booby.

SURVEY REPORT

1. Methods

Despite the immense difficulties of recording birds high in tree canopies over difficult terrain, we are convinced that the survey has produced the first detailed and accurate map of Abbott's Booby sites on Christmas Island. D. A. Powell, J. Tranter and H'ng Kim Chey are to be congratulated on this achievement.

The report of the survey consists of four parts: (1) a description of the methods used; (2) maps showing the distribution of Abbott's Booby sites in 1979-80; (3) graphs and tables of the numbers of Abbott's Boobies seen flying to the Island in 1979 and 1980; and (4) an analysis of the nesting habitat preferences of the species.

Abbott's Booby sites were located during a detailed survey of the Island and mapped using a grid of reference squares with sides of 400 ft (122m). Because of the great difficulty of covering the total area (some 8000ha of rainforest) and the situation of many nests over 20m up in the canopy of tall trees it was impossible to identify all breeding nests. The survey records 'sites' whose status was defined in a number of ways, all indicating some degree of occupancy by Abbott's Booby but not necessarily breeding. Some minor discrepancies occur in the survey report in that for a few blocks the number of sites plotted in the blocks does not equal the total given on the map. The total figures used in this appraisal accord with sites as plotted.

For the purpose of this appraisal a site is a place or tree where during the 1979-80 survey, Abbott's Booby droppings, nests, chicks or juveniles were recorded. The status of many sites is based on a single observation during the two year study

period and since the status may change the sites have been grouped as a whole to indicate Abbott's Booby habitat on the Island.

2. Population Dynamics

The application of the survey results to the making of management decisions must take account of other information about the biology of the species, such as that presented in Nelson (1971, 1977 and 1978) and Nelson and Powell (unpublished manuscript). Some aspects of the breeding habits of the species are now fairly clear, others are not. For instance the difficulty of capturing birds means that very few have been banded, making it impossible to draw conclusions about the movements of individual birds and their history.

Summarising the above work of Nelson and Powell, it is known that the mature female lays only one egg, on average only once in two years. Some eggs (probably 10 - 30%) fail to hatch and of the hatchlings probably less than 38% survive to the stage where they are independent (after about one year) of their parents. During the following period of four or five years until the birds reach maturity, it seems about a further 50% of those surviving the first year perish. Thus, it appears that of the eggs laid by each breeding pair, on average only one of the eggs laid over a thirteen year period develops to become a breeding adult.

The length of the breeding life of the adults is unknown but if the previous information is correct, clearly the breeding life would have to exceed twenty-six years to enable each pair to reproduce itself and keep the population in balance. If the life expectancy is as long as this, Abbott's Booby is one of the most long-lived seabirds known. If this is not the case the species numbers must be declining. Any species

with such a life cycle and with its breeding limited to one Island is clearly placed at risk by habitat change on the Island. With continuing destruction of breeding sites a point could be reached where the species is at minimum viable level of population and unable to withstand further loss of habitat sites.

3. Distribution of Abbott's Booby Sites

Map 1 of the survey report by Powell and Tranter shows the distribution of Abbott's Booby recorded during the survey period 1979-80. In Figure 2 these are plotted in relation to the mining blocks and the national park.

Direct comparison with the map of sites given by Nelson (1971), based on his 1967 study, must be made with circumspection. Certain densely vegetated areas of the Island were visited only briefly by Nelson and probably he failed to record all existing sites. The likelihood of this was confirmed during the discussions with Mr. Powell. In 1967 Nelson recorded birds in two or three areas which are no longer used but the reason for the abandonment of these areas since then is unknown. There are no major areas where the birds are found now but where they did not occur in 1967.

Of the sites located by Powell and Tranter, most were not successful breeding sites. Whilst it is impossible to identify all successful breeding sites, the sites where a free flying juvenile was seen between June and December 1979 or 1980 provide an indication of successful breeding. The birds at these sites would have been born in the previous year and survived the early period of high chick mortality. Nestlings which survive to June are considered likely to survive until they are independent of their parents.

Examination of the distribution of these 'successful sites', which constitute only 14% of all sites, shows they are not concentrated in certain areas but tend to be fairly constant in proportion wherever there are sites of any kind. This suggests that there is no broad difference between site areas in breeding success.

4. Population Size

Powell and Tranter do not attempt to assess the population size of Abbott's Booby. Graphs and tables are provided of the numbers of birds seen flying into the Island from the direction of their feeding grounds at the time of day when the birds return. Counts obtained in a similar way were used by Nelson (1971 and 1977) to estimate the total population of the species using reasonable but at present unsubstantiated assumptions. Such estimates are the best available but since they may be in error, it is dangerous to use them as a basis for management decisions. The difficulty of obtaining an accurate population number for Abbott's Boobies derives from the fact that many pairs do not attempt to breed every year and that much of the population (perhaps one quarter to one half) consists of immature birds independent of their parents and these immature birds visit the Island infrequently, if at all.

Whilst counts of the number of in flying birds do not permit accurate calculations of the number of Abbott's Boobies, they set a minimum figure. Thus on one day in July 1979 a total of 3358 were recorded flying in over a four-hour period. Probably there were a few hundred additional birds on the Island at the time. Consequently the total population of Abbott's Booby must exceed 3500, and this confirms earlier estimates.

However, it is impossible to say whether the population is closer to estimates of 5,000 - 5,500 (Nelson, 1971) or 8,000 -

10,000 (Nelson, 1977). These two different population estimates cannot be taken to indicate any change in numbers from 1971 to 1977. As emphasised by Nelson, the difference reflects the great difficulty of arriving at an accurate number. Inevitably the standard error associated with such estimates is large and it is imprudent to use them to monitor population change until more is known about the biology of Abbott's Booby.

5. Response to Habitat Destruction

A critical consideration is the impact of clearing on birds whose nesting trees are destroyed for mining. Although the adult birds may not suffer immediately, unless they succeed in re-establishing themselves in new sites and breeding successfully - not necessarily the same thing - the rearing of young birds to independence will be impaired. Increasing density of nesting pairs at the remaining sites and the breakdown of the bond relationships of a nesting pair may result in a delay in the breeding cycle or a temporarily diminished success such as occurs in other seabirds. The impact of clearing would only become apparent several years afterwards and if adverse would result in a dwindling recruitment of young adults into the breeding population and cause a species decline.

Because it is impossible to recognise individual birds, only indirect evidence is available about this key problem of the response to site destruction. It seems certain that pairs normally return to a site where they have previously nested. Pairs displaced by loss of a site probably re-nest in the same neighbourhood if a suitable tree is available. At Block 22, Nelson and Powell (1977) found that when many sites were cleared the number of sites increased greatly in the neighbouring trees. Such local resettlement depends on the presence of suitable sites in close proximity.

The conservatism of the boobies, shared with most species of seabirds, probably means that they are unwilling to prospect for new nesting sites some distance from where they previously nested. Whilst direct evidence for this is difficult to obtain for Abbott's Booby, it is significant that despite the displacement of some birds after the 1967 survey no new areas have been colonised which were not close to existing groups of sites.

Even when nesting trees remain, the clearance of areas nearby can create a hazard. Such open areas permit harassment by pirate frigatebirds which chase boobies to make them regurgitate food. Their targets include adults returning to feed their young (at certain stages of the breeding cycle parents return only once a week). Furthermore, newly fledged young, which when harassed crash land on the ground in the open, have a more difficult task in taking off than when they fall on the crowns of surrounding trees.

6. Site Preference

The availability of suitable nesting trees is less than might be expected from the area of remaining rainforest. The birds have a strong preference for certain species of trees and their choice is further constrained by the aspect and detailed physiography of a site. Because of their flight style the boobies need emergent trees rising above the main canopy with clear access to the north west and away from the prevailing wind.

In commenting on the survey results Powell and Tranter point out that 98% of all recorded Abbott's Booby sites are on trees of Planchonella nitida, Eugenia gigantea, Celtis cinnamomea, Tristiropsis nativitatis, Ficus saxophila and Pongamia pinnata and about 70% on trees of the first two species. Topography, protection from winds and gregariousness

are also identified as important influences on site selection by Abbott's Booby.

Clearly the distribution of Abbott's Booby sites over the Island is determined by a number of interacting factors. Large areas of forest do not have sites meeting the requirements. The preservation of an adequate area and number of suitable sites is critical to the survival of the species since the problems faced by a long-winged seabird in nesting in a dangerous tree-top environment are formidable.

EFFECTS OF MINING

1. Abbott's Booby Sites and Mining Blocks

Areas on the Island with phosphate ore deposits suitable for mining are divided by the British Phosphate Commission into blocks as shown in Figure 2. Usually only part of a block is cleared for mining and this is called a mining field.

The areas already cleared and the areas proposed for clearing are shown in Figures 3 to 20 for eighteen blocks with Abbott's Booby sites (blocks 11, 15, 18, 18D, 19, 19A, 19B, 20, 21, 22, 22A, 22C, 23, 23A, 24, 25, 26 and 27)(Table 1). Of these eighteen blocks, further clearing is proposed only for the ten blocks 18D, 19, 19B, 21, 22, 22A, 24, 25, 26 and 27. In blocks 11 and 22C some trees have been left in mining areas to protect immature birds and these will be cleared.

On the Island there are three other blocks with sites namely P1, 9 and 12. No mining is proposed for block P1. It is understood the clearing proposed for block 12 will not affect the only site there. In block 9, three sites may be at risk.

The total number of sites in the twenty-one blocks with sites was 1011 and of these 37 (3.7%) are on cleared areas and therefore doomed since the trees are felled once the nestling leaves the nest; 109 (10.8%) are on areas proposed for clearing and 865 (85.6%) are outside the cleared or proposed for clearing areas (Table 1). Clearing may cause some loss of the sites outside the cleared areas by exposure and windblow of marginal trees whilst the success of breeding at others may be reduced as a result of clearing.

2. Abbott's Booby Sites on Christmas Island

The number of Abbott's Booby sites recorded in the Survey was 1761 (Table 2). It is possible that some have been overlooked but this is unlikely and in that event the number missed would certainly be small.

If the mining plans are implemented as proposed in Figures 3 - 20, the number of existing sites that would be lost as trees are felled in areas already cleared or proposed for clearing respectively would be 37 and 109 i.e. equal to 2.1% and 6.2% of the total number of Island sites. If it is assumed there is no effect of clearing on the existing sites outside the cleared or proposed clearing areas, then 91.7% of all existing sites would be retained, 20.6% being in the National Park.

LAND MANAGEMENT

1. Habitat Protection

Extinction is forever. Unless a mining programme is implemented which makes provision for the long term protection of habitat, it is improbable that the species will survive. Management to protect the species must be orientated to the

protection of its habitat on Christmas Island. Of particular concern is the retarding effect on recruitment to the population resulting from the clearing of occupied areas. As the available habitat declines, the base from which recruitment can take place is reduced.

The Abbott's Booby sites identified during the Survey combine certain specific features. The number of such sites on Christmas Island which meet these criteria is probably limited.

Since mining began on the Island much Abbott's Booby habitat has been lost, how much cannot be known. It is possible that the species could survive some further loss of habitat but there is no guarantee of this and little guidance as to what further reduction is possible without jeopardising the survival of the species. The problem is compounded because of the life cycle and habits of the species, the prolonged period of adolescence and the difficulty of accurately counting the population. Changes which lead to an irreversible decline and ultimately extinction cannot be detected quickly. Furthermore the ability of the species to recover from an increasingly depleted stock becomes ever more difficult.

2. Management Options

An examination of the distribution of sites in individual blocks (Figures 3 - 20) shows that with care in clearing and the application of sensitive restoration measures many sites could be kept, especially those sites outside the production areas. This would allow phosphate to be mined with little loss of output, perhaps at a slightly higher cost, but would protect important sites (Table 3) outside the production areas.

Where mining fields have been cleared and isolated sites left until the young birds leave the nests, these sites could be cleared and mined. It is understood from past experience that the trees die because of exposure.

Various management options can be identified ranging from the preservation of all the remaining sites in blocks with Abbott's Booby sites by banning new mining there to the other extreme of permitting mining to proceed as planned (Table 4).

The five blocks with the greatest numbers of Abbott's Booby sites are 22, 22A, 25, 20 and P1 with 174, 168, 139, 108 and 102 sites respectively. No further clearing is proposed on blocks P1 and 20 so that the sites in blocks 22, 22A and 25 are those of immediate concern. Because of the large number of sites in blocks 22, 22A and 25 there is merit in delaying mining in the blocks whilst proceeding with mining elsewhere.

Block 22A is of particular significance because of the large number of sites, high site density, its relatively undisturbed nature, the forest cover and because it adjoins the national park. Whilst it contains grade A phosphate the cost of extraction could be greater than normal because of its isolation, the scattered nature of the deposits and the high cost of roads. The amount of habitat disturbance by mining in this block is likely to be relatively large extending beyond any areas that are cleared.

In contrast, clearing for mining has already taken place in blocks 22 and 25. In consultation with the Conservation Officers adjustment of the present mining plans for these blocks could be made which would open up some of the block for mining whilst retaining most of the existing sites.

During a discussion with officials of the Trade Union representing Christmas Island workers it was suggested that the

rate of mining should be decreased so as to extend the life of the industry beyond the proposed "optimum" plan of six to seven years production at current export specifications. This suggestion by the Trade Union officials could be helpful to Abbott's Booby in providing more time for any resettlement by the birds.

3. Boobies or Phosphate or Both

Assessments may be made of the consequences of conserving Abbott's Booby in terms of phosphate production foregone, and thus of employment opportunities lost. Of necessity such assessments are complex and need to be interpreted cautiously.

Whilst the current distribution of Abbott's Booby sites on Christmas Island is now reasonably known, information about the phosphate resource appears less precise. Estimates of the amount of phosphate ore now left on the Island and of the number of years remaining for mining change with the progressive refinement of field surveys. Any estimation is complicated by the need to take into account stockpiling of ore, proposals to rework old fields, the mixing of ore of different grades, changes in processing techniques and the varying needs of different export markets. Economic and employment considerations (both on Christmas Island and in Australia) are also important and have to be considered on various time scales.

Such assessments of the relative values of boobies or phosphate ore were seen by the panel as beyond the terms of this appraisal. However, information on the phosphate reserves is given in Table 5. These figures relate solely to grade A ore which is blended with poorer grades so enabling use to be made of less rich material. From the detailed block maps (Figures 12 and 18) it is evident that much of the ore in blocks 22 and 25 would

continue to be available for mining if the plans for these blocks were revised to retain sites threatened by the current proposals.

Through co-operation between conservation and mining interests it should be possible to develop a mining plan more sensitive to nature conservation than was possible in the past without placing unacceptable constraints on the industry. We believe the necessary expertise is available in the officers of the different organisations. It is important that once approved such a plan should not be changed without agreement between the various interests. It should identify all areas to be cleared for mining and associated works and include checking procedures to ensure forest clearance is confined within the boundaries as agreed and prescribed.

A good basis for such co-operation is seen in the friendly working relationships developed between officers of the Administration, Australian National Parks and Wildlife Service and the British Phosphate Commissioners and in the increasing interest in nature conservation being shown by people living on the Island.

We believe that with a revised mining plan, jungle clearing for phosphate mining can be compatible with the conservation of Abbott's Booby and that the conservation of this species may in the long term be important to the future of Christmas Island and its people. The recent visit to the Island by the ocean tourist ship Lindeblad Explorer is an indication of the potential to develop tourism, especially science based tourism related to wildlife, as an industry.

RECOMMENDATIONS

Because mining, as currently planned, will only destroy 8.3% of the existing sites of Abbott's Booby, it might be

considered that this does not pose a serious threat to the species. However, it must be remembered that past mining has destroyed many sites and the species may be at, or approaching, a critical minimum population level below which it cannot sustain itself in the longer term. Therefore we believe it is essential:

(1) to proceed cautiously with any further clearing for mining;

(2) to have a system of checking to ensure that clearing does not extend beyond prescribed limits; and

(3) to foster rehabilitation and reafforestation programmes.

On the assumption that mining should continue and that Abbott's Booby must not be placed in danger of extinction the following recommendations are made:

1. Clearing for phosphate mining should be permitted in the mining fields of all blocks without Abbott's Booby sites.

2. Clearing for phosphate mining as proposed should be permitted in the fields of blocks 18D, 19, 19B, 21, 24, 26, 27, 11, 15, 18, 19A, 20, 22C, 23 and 23A. Every care should be taken not to disturb sites outside the areas already cleared and in the new production blocks by redefining the new areas to be cleared and by the control of all field operations associated with mining.

3. Particular attention should be paid to the location of roads and stockpiles to locate them away from Abbott's Booby sites.

4. For reasons stated previously block 22A is of considerable biological significance and should not be mined.

5. There is no proposal to mine block P1 and no clearing should take place in this block.

6. Some mining could occur in blocks 22 and 25 provided that the relevant mining plans are reorganised in consultation with the Conservators so as to provide permanent protection to most, if not all, of the sites in areas currently proposed for clearing.

7. If possible, any clearing for mining in blocks 22 and 25 should be timetabled to take place near the end of mining operations on the Island and revised in the light of the status of Abbott's Booby after further monitoring.

8. Powell and Tranter in their survey make a number of recommendations with regard to clearing procedures, excess clearing, revegetation and fragmentation of habitat. These should be implemented.

9. Adequate funds and resources should be provided to support studies of the breeding success of Abbott's Booby, analysis of the habitat of Abbott's Booby and the impact of mining on the population. The survey of the distribution of Abbott's Booby sites and the counts of birds

flying into the Island have provided valuable information. They should be repeated at least twice in the next six years as an integral part of an overall research programme.

10. The Commission of Inquiry (Sweetland, 1980) recommended that the reafforestation programme should be expanded and that bird populations should be monitored as accurately as possible so that any signs of significant decline can be detected and appropriate actions taken. This recommendation is supported.

CONCLUSIONS

Of all the options given in Table 4, option 6 best meets the ten recommendations, provided that the proposals are implemented to improve the field clearing and excavation procedures and to carry out further monitoring. Some losses both of existing Abbott's Booby sites and phosphate ore for mining would be involved.

This appraisal is concerned only with the impact of further mining on Abbott's Booby and no consideration has been given to the effects on other species.

ACKNOWLEDGEMENTS

We wish to record our appreciation of the many people on Christmas Island who assisted us and in particular the Administrator the Hon. R. McN. Holten, R. Elliott, N. Brown, D. A. Powell, J. Tranter and J. Hicks. J. S. Hoare the Chief Engineer of the British Phosphate Commissioners stationed in Melbourne helped us in numerous ways and we are grateful to him.

REFERENCES

Anon. 1974. Conservation of Endangered Species on Christmas Island. Report from the House of Representatives Standing Committee on Environment and Conservation. Australian Government Publishing Service, Canberra. 45pp.

Nelson, J. B., 1971. The biology of Abbott's Booby Sula abbotti, Ibis, 113: 429 - 467.

Nelson, J. B., 1977. Report and Recommendations on the Status and Prospects of Abbott's Booby in Relation to the British Phosphate Commissioners' Mining and Conservation Policy, unpublished report: 21pp and map.

Nelson, J. B., 1978. The Sulidae: Gannets and Boobies, Oxford. University of Aberdeen and Oxford University Press: 751 - 808.

Nelson, J. B., and Powell, D. A. (Unpublished manuscript). The breeding ecology of Abbott's Booby.

Powell, D. A., and Tranter, J., 1981. The Distribution of Abbott's Booby: Christmas Island 1979-80, unpublished report: 33pp and maps.

Sweetland, W. W., 1980. Report of Commission of Inquiry into the viability of the Christmas Island Phosphate Industry, Canberra. Australian Government Publishing Service: 112pp.

Table 1 Number of Abbott's Booby sites in mining blocks

	Block		Number of Abbott's Booby sites in mining blocks			
	number	area ha	Left temporarily in cleared area until young bird leaves nest	In areas of proposed clearing	Outside the areas cleared or proposed for clearing*	Total
Blocks with some new proposed clearing	9	195	0	0	3	3
	12	148	0	0	1	1
	18D	239	0	2	13	15
	19	69	0	1	53	54
	19B	123	0	0	35	35
	21	213	0	1	34	35
	22	196	13	25	164	202
	22A	149	0	23	144	167
	24	100	0	2	24	26
	25	265	10	41	82	133
	26	206	0	6	9	15
	27	146	2	8	11	21
Total	12	2049	25	109	573	707
Blocks** with no clearing proposed	P1	91	0	0	102	102
	11	200	4	0	0	4
	15	187	0	0	13	13
	18	115	0	0	5	5
	19A	66	0	0	4	4
	20	172	0	0	108	108
	22C	113	8	0	39	47
	23	53	0	0	14	14
	23A	131	0	0	7	7
Total	9	1128	12	0	292	304
TOTAL	21	3177	37	109	865	1011

* Some of these sites could be at risk from road construction, other works and where they are close to clearings.

** In blocks 11 and 22C sites left to protect nestlings in mining fields will be cleared.

Table 2 Abbott's Booby sites on Christmas Island (Figures in brackets are percentages of all sites on Christmas Island recorded in 1979-80 survey)

	Area in ha	Number of sites	Number of sites directly at risk by clearing for mining as proposed
Christmas Island as a whole	13,300	1,761 (100%)	146 (8.3%)
Christmas Island National Park	1,600	363 (20.6%)	0 (0%)
Not included in national park or mining blocks	8,523	387 (22.0%)	0 (0%)
Blocks* 9, 12 18D, 19, 19B, 21 22, 22A, 24, 25 26, 27	2,049	707 (40.1%)	134 (7.6%)
Blocks** P1, 11, 15, 18, 19A, 20, 22C, 23, 23A	1,128	304 (17.3%)	12 (0.7%)

* In these blocks new clearing is proposed as well as clearing of any sites left temporarily in mining fields until the young bird leaves the nest.

** In these blocks no new clearing is proposed but in blocks 11 and 22C sites left temporarily in mining fields until the young bird leaves the nest will be cleared.

Table 3 Number of Abbott's Booby sites in proposed new jungle clearing but outside production blocks (Figures 3 - 20)

Block number	18D	19	21	22	22A	24	25	26	27
Number of sites	2	0	1	21	15	0	13	2	1

The number of sites in this category in the 9 blocks is 55.

Table 4 Consequences of some management options in terms of Abbott's Booby sites. (It is assumed that mining is done in such a way that no sites are affected by roads and other works.)

Options	Direct loss of sites including sites left as small patches until young birds leave the nest	Sites left on Christmas Island	Sites left as percentage of Island sites recorded in 1979-80 survey
1 Mine as proposed	146	1615	91.7%
2 Mine as proposed but exclude block 22A	123	1638	93.0%
3 Mine as proposed but exclude marginal sites (Table 3)	91	1670	94.8%
4 Mine as proposed but exclude block 22A and marginal sites (Table 3)	83	1678	95.3%
5 Mine as proposed but exclude block 22A and in blocks 22 and 25 revise mining plan to protect nest sites in areas of proposed clearing	57	1704	96.8%
6 Mine as proposed but exclude block 22A and marginal sites (Table 3) and revise mining plans of blocks 22 and 25 to protect sites in areas of proposed clearing	50	1711	97.2%
7 No mining in blocks with Abbott's Booby sites except for patches left in mining fields until young birds leave nests	37	1724	97.9%

Table 5 Estimated amount of recoverable A grade ore remaining (Information supplied by officers of the British Phosphate Commissioners on 21 January 1981.)

	Million tonnes	Percentage of recoverable ore left on Island after past mining	
Block 22A	0.175	1.9%	
Block 22	0.160	1.8%	
Block 25	2.400	26.7%	Much of this ore could be mined with revised mining plans to protect Abbott's Booby sites
Christmas Island	9.000	100.0%	

Recoverable and currently marketable A grade ore reserves are 81.8% of the total geological phosphatisation of A grade ore on Christmas Island (11 million tonnes).

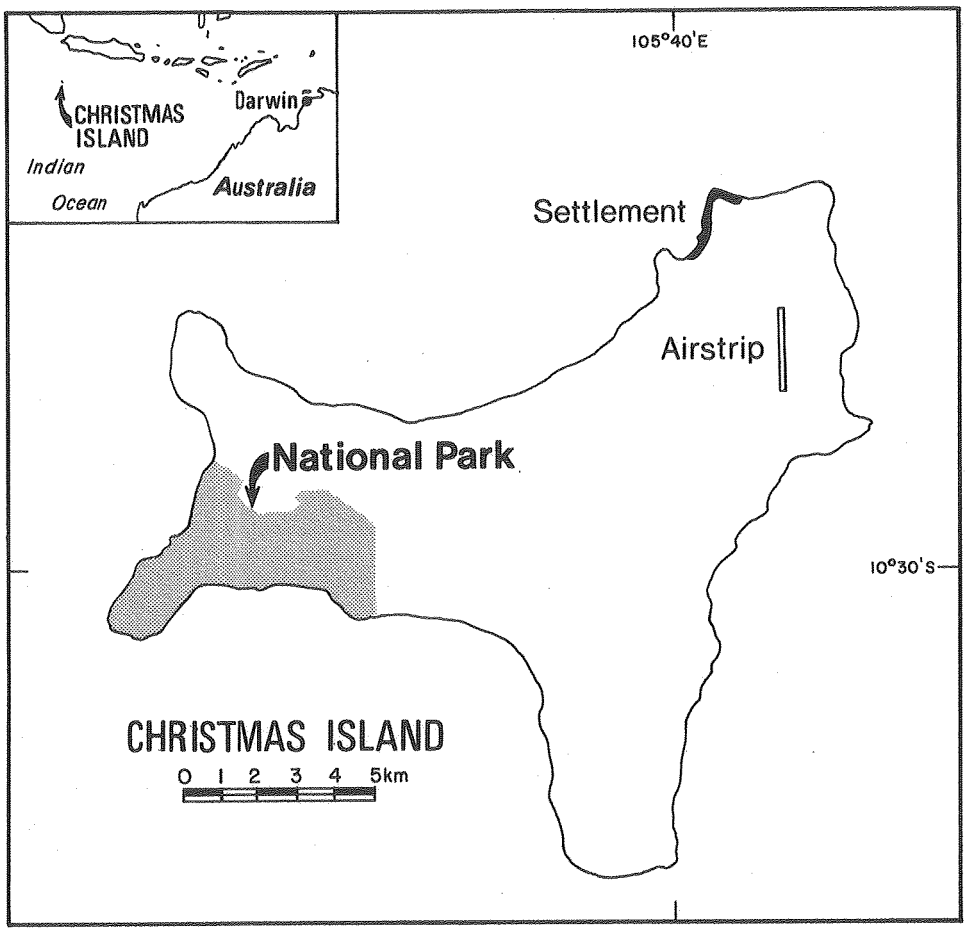


FIGURE 1 CHRISTMAS ISLAND

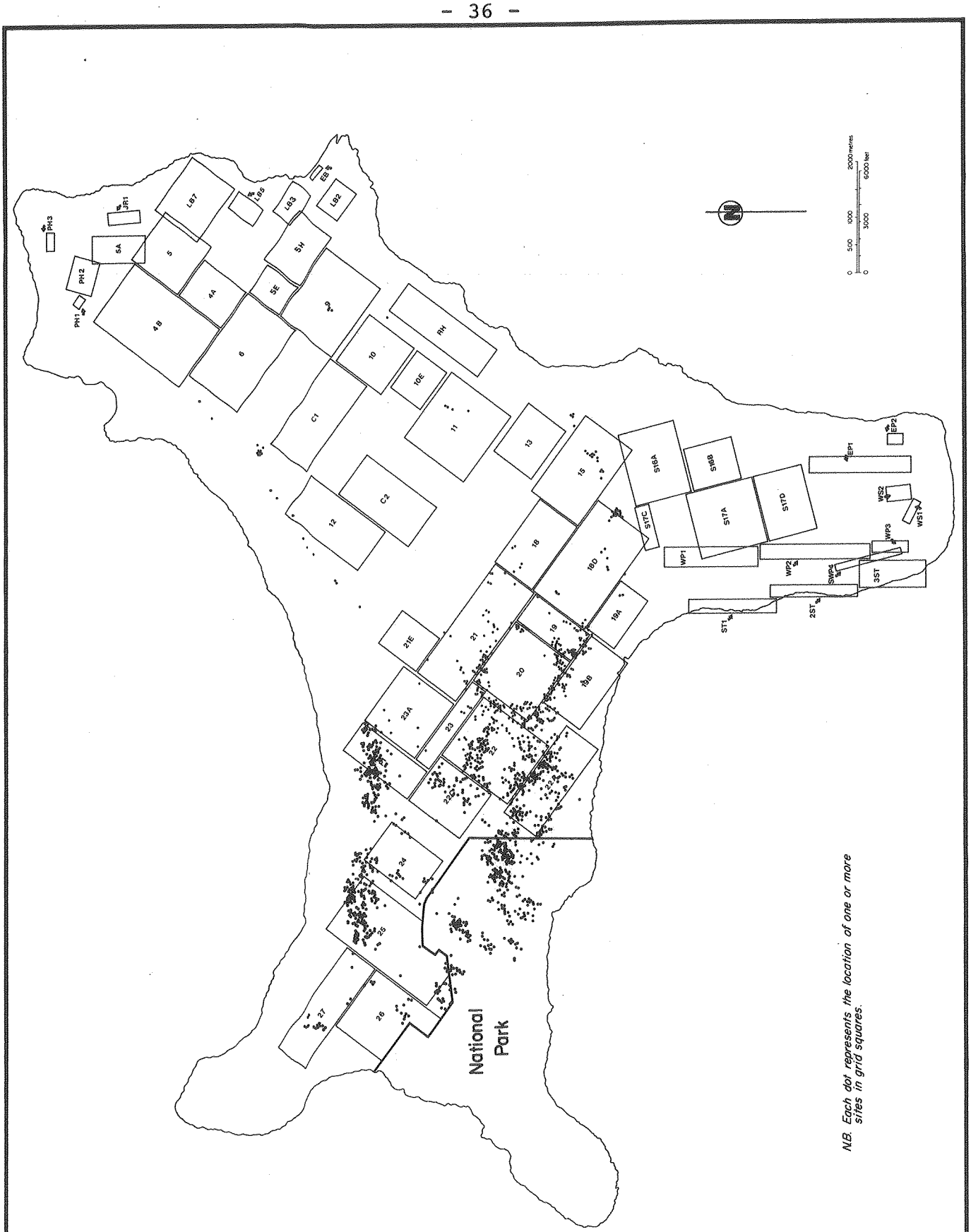


FIGURE 2 MINING BLOCKS, NATIONAL PARK AND THE DISTRIBUTION OF ABBOTT'S BOOBY RECORDED IN 1979-80 SURVEY

LEGEND FOR FIGURES 3-20

Preliminary proposed jungle clearing

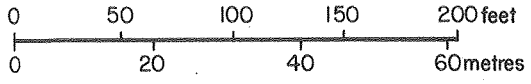
Existing jungle clearing

Production block outside existing jungle clearing boundary

Block boundary

NUMBERS OF BOOBY SITES

- *1*
- *2*
- *3*
- *4*
- *5*



N.B. The grid lines (in feet) are indicated for each block.

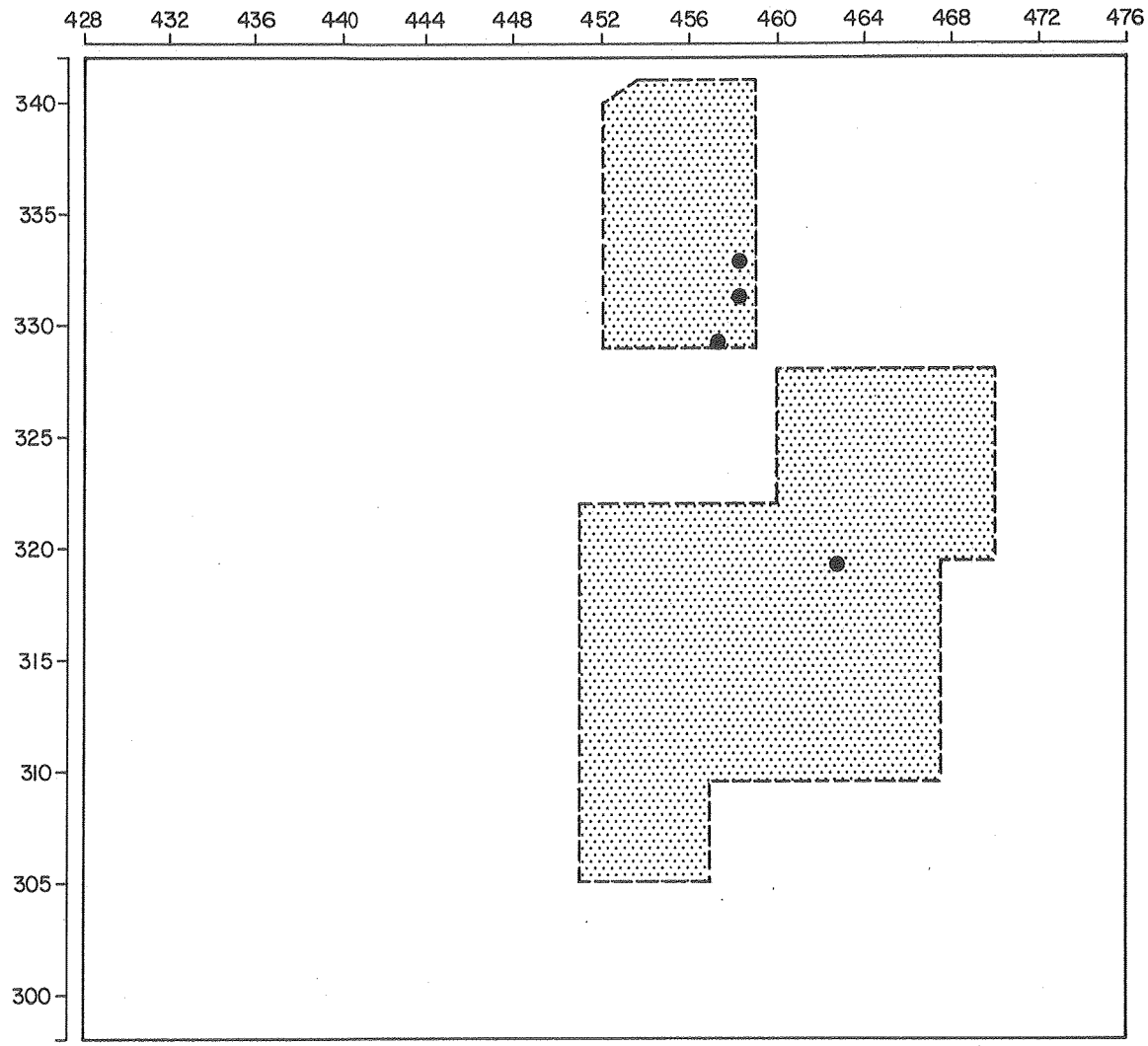


FIGURE 3 Block 11

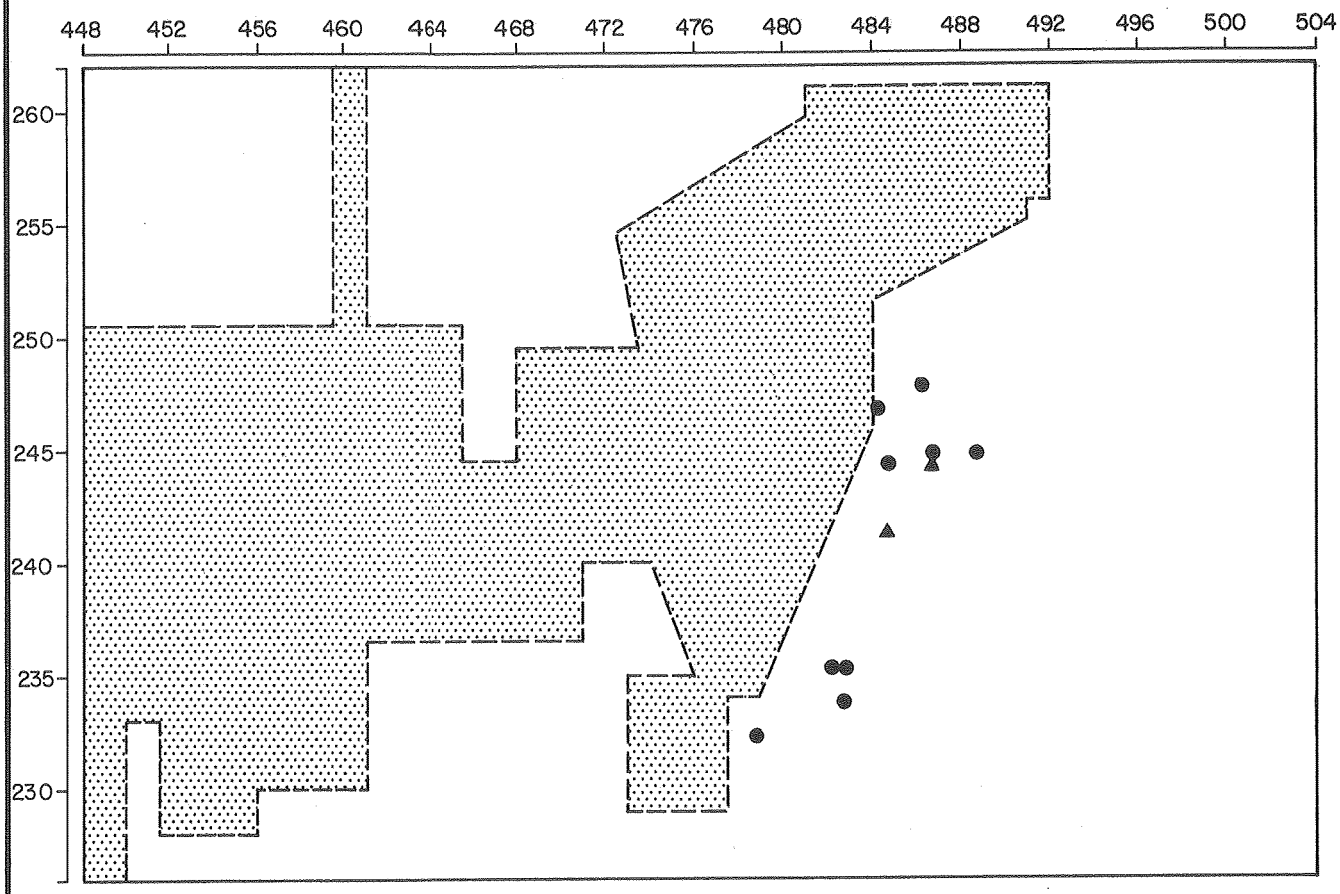
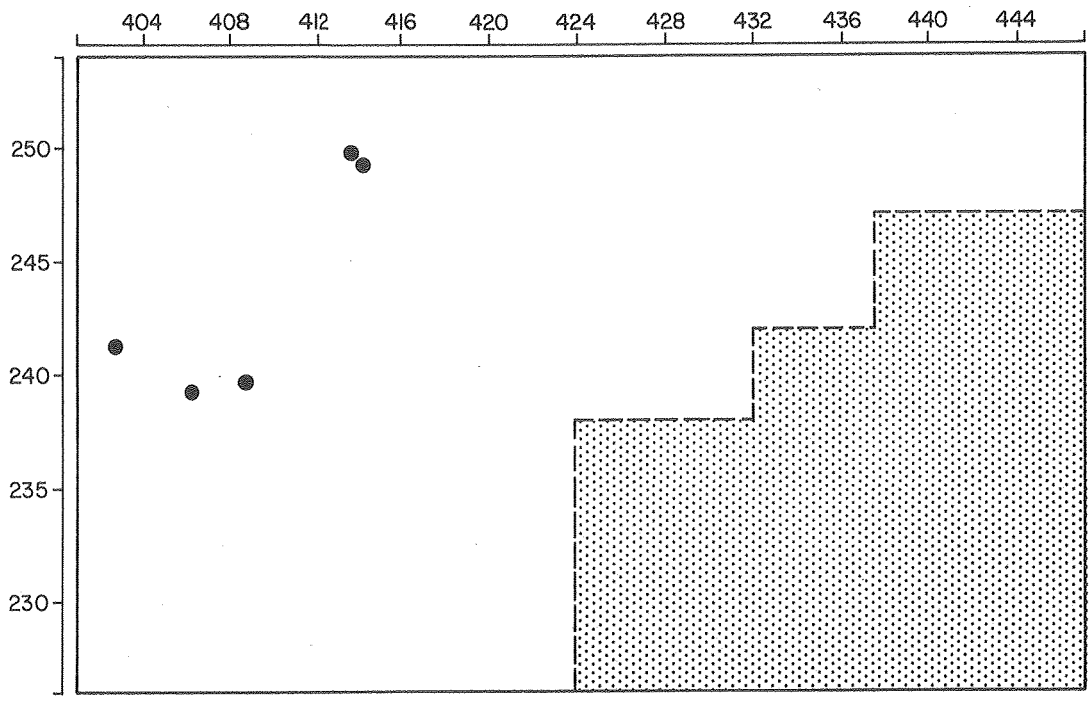


FIGURE 4 Block 15



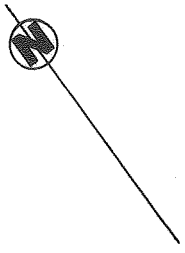


FIGURE 5 Block 18

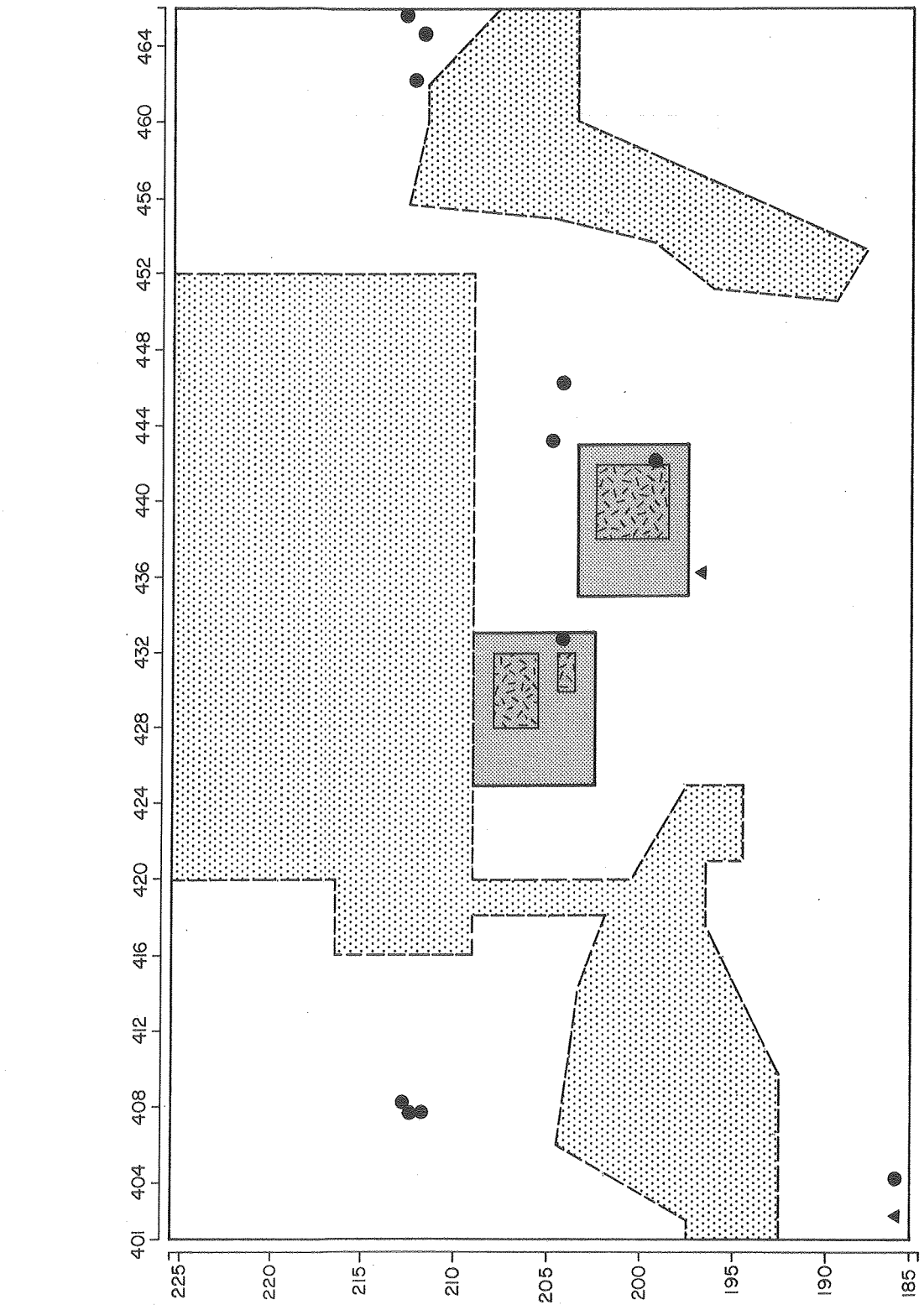


FIGURE 6 Block 18D

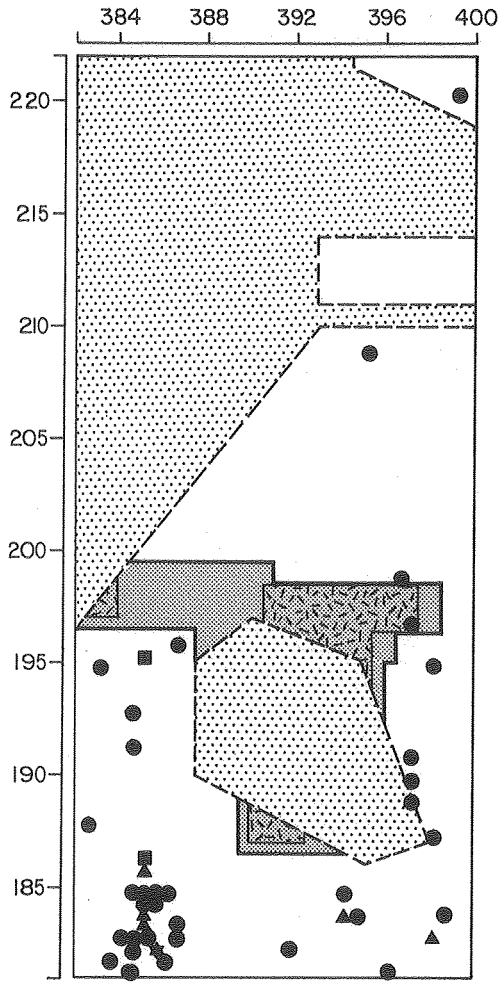
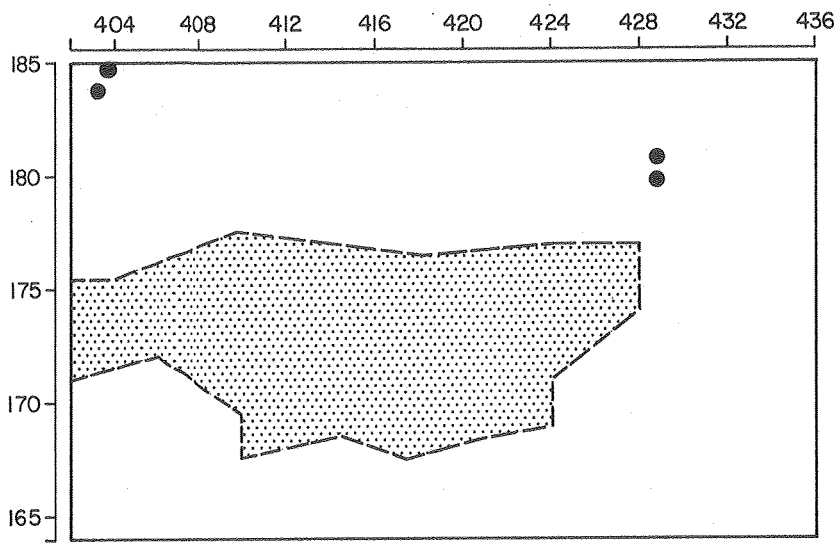


FIGURE 7 Block 19



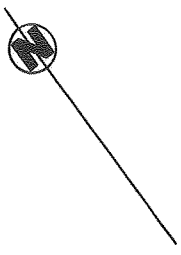
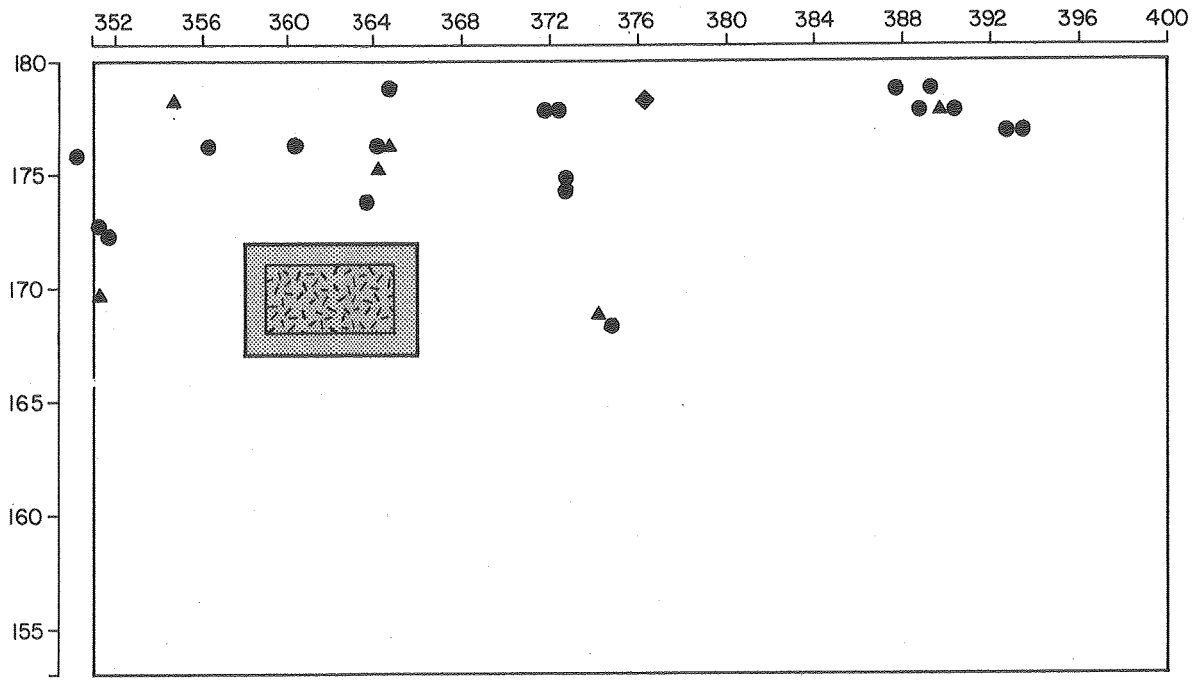


FIGURE 8 Block 19A



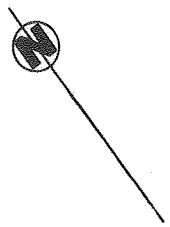
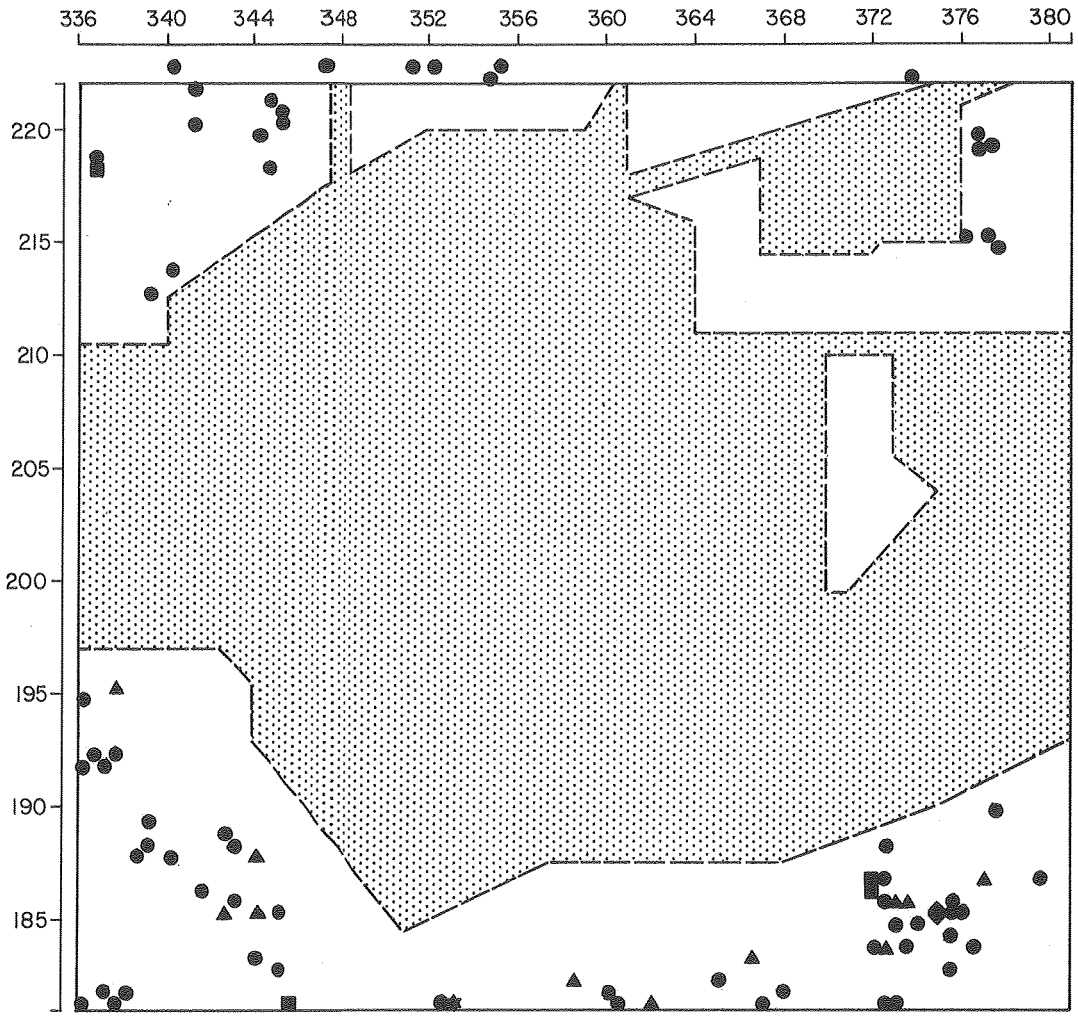


FIGURE 9 Block 19B



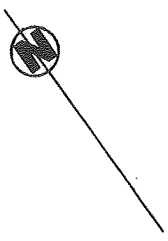


FIGURE 10 Block 20

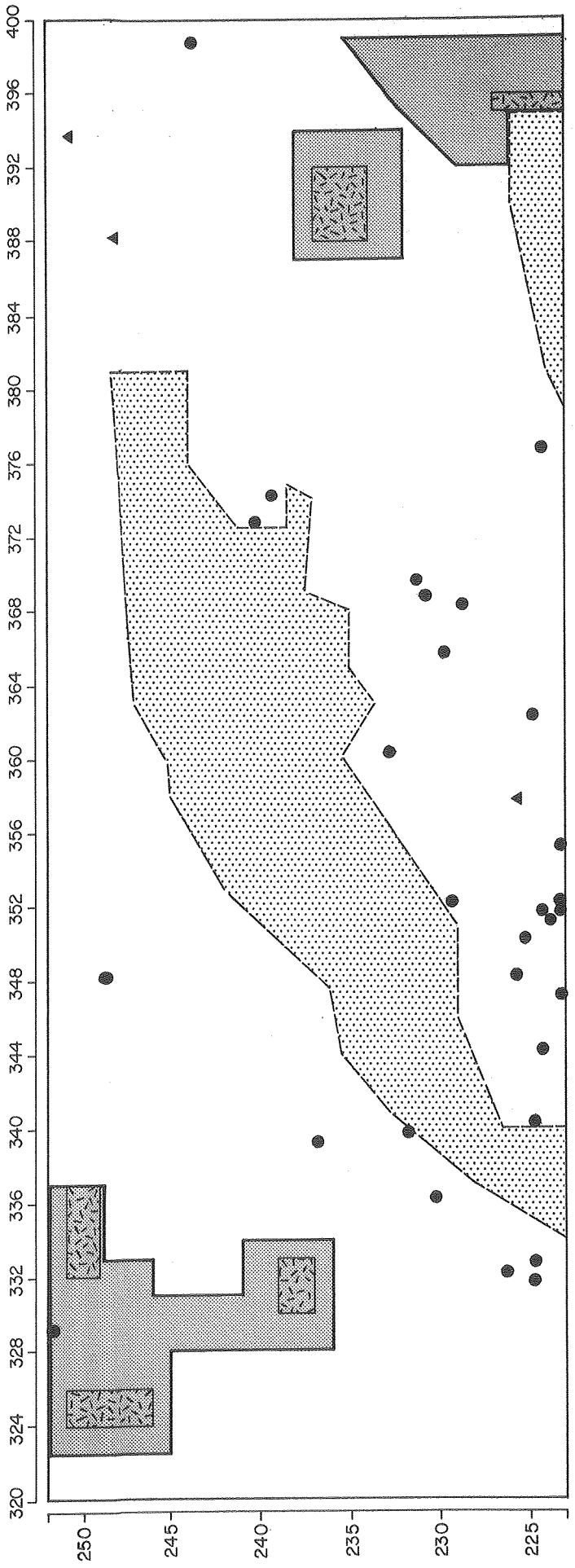


FIGURE 11 Block 21

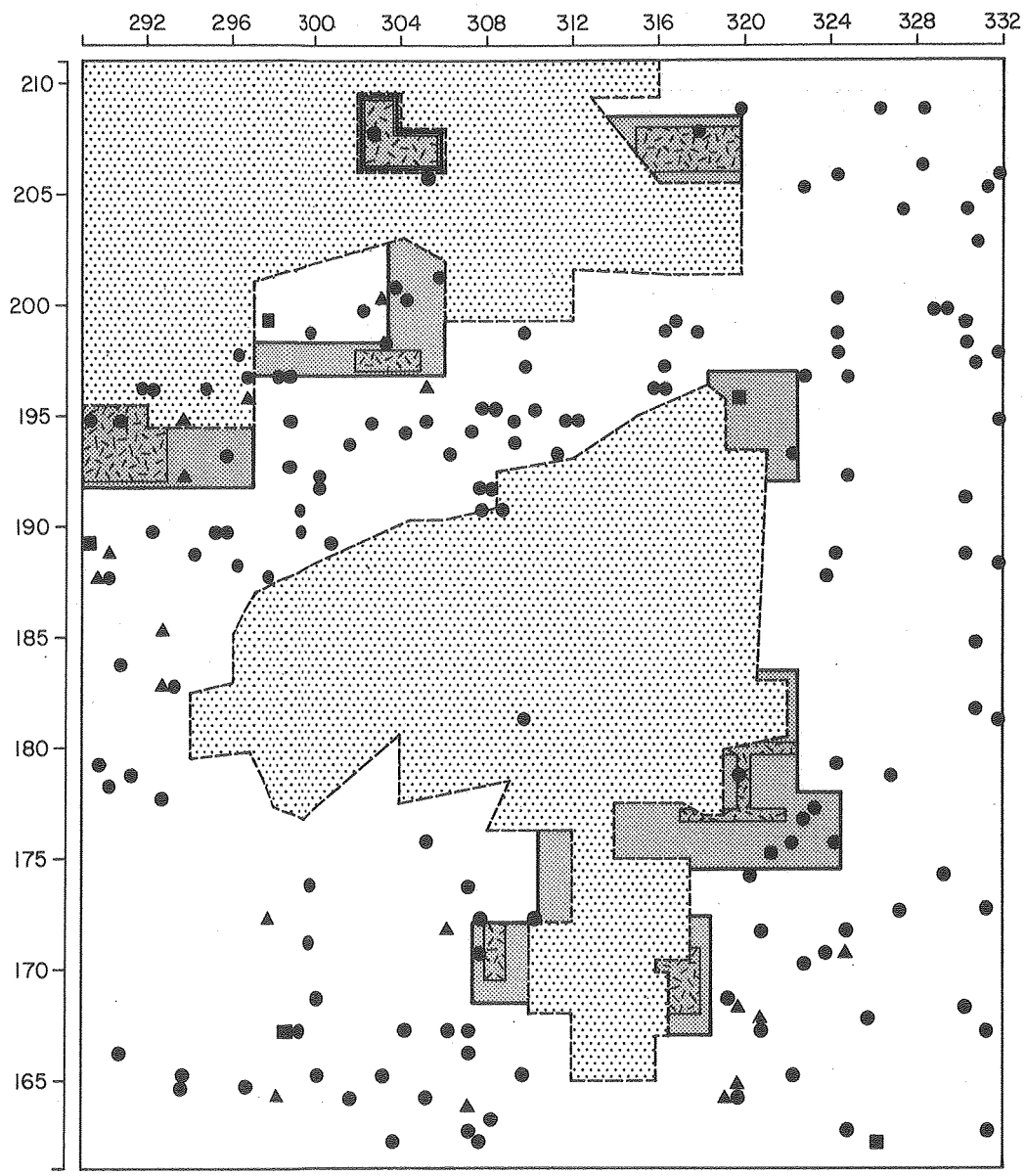


FIGURE 12 Block 22

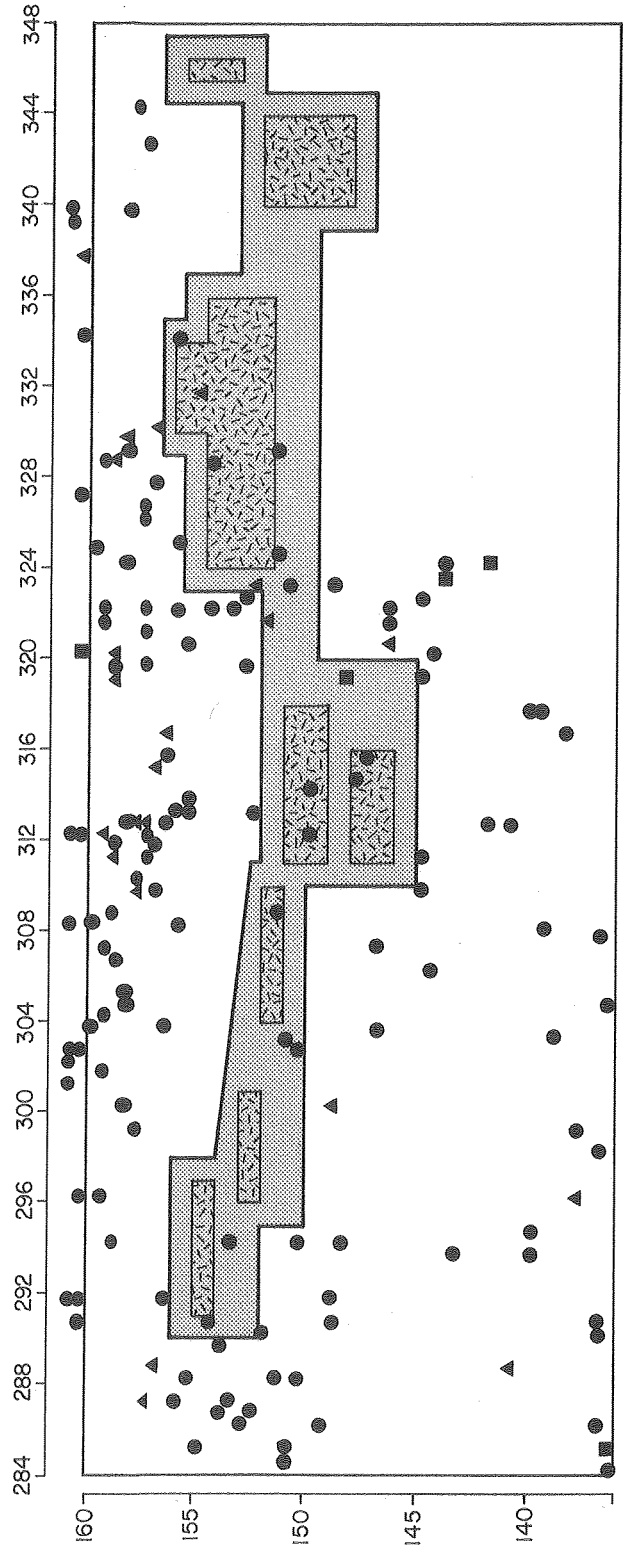
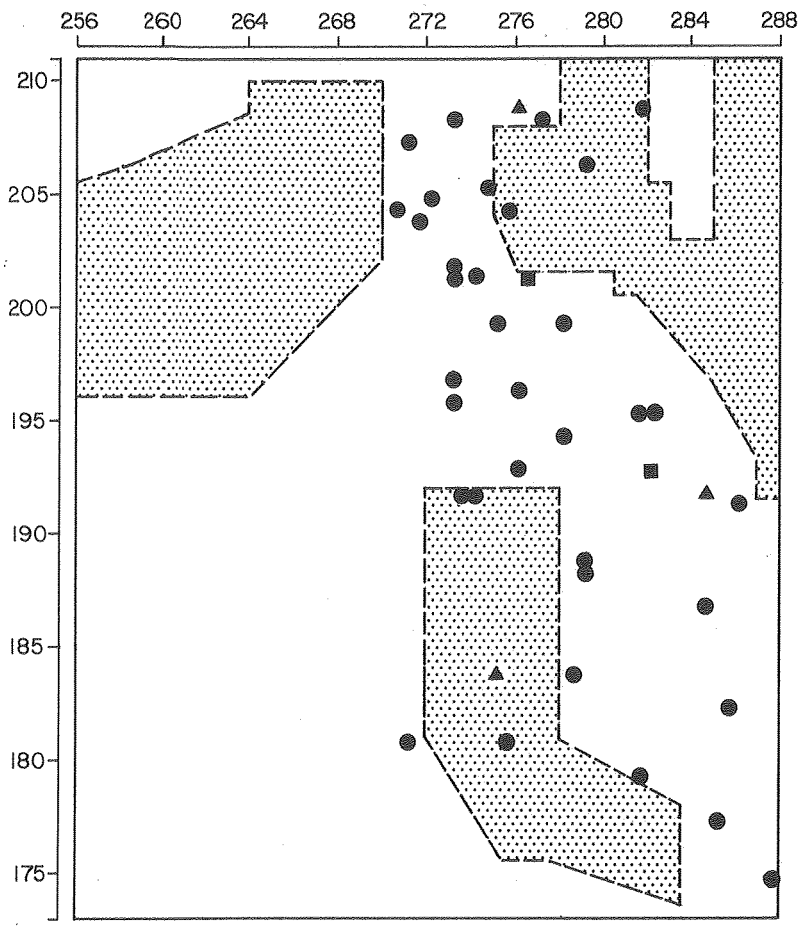


FIGURE 13 Block 22A



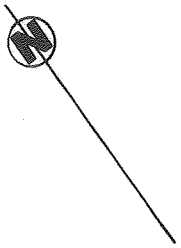
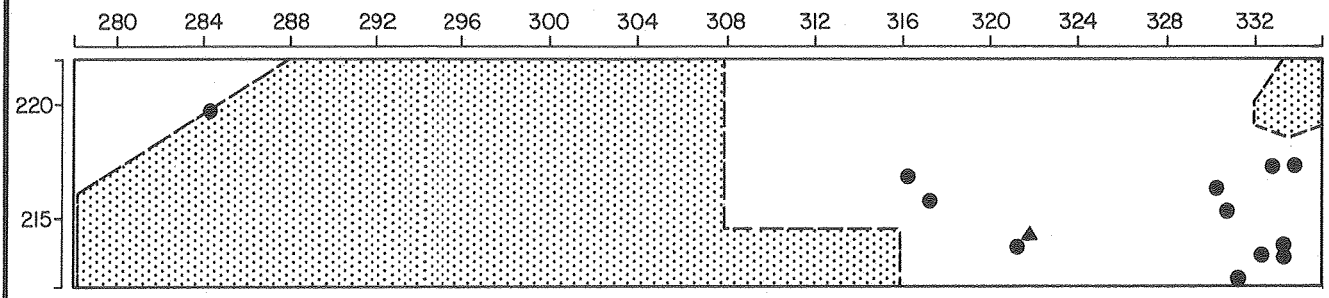


FIGURE 14 Block 22C



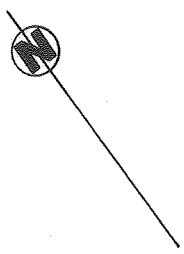
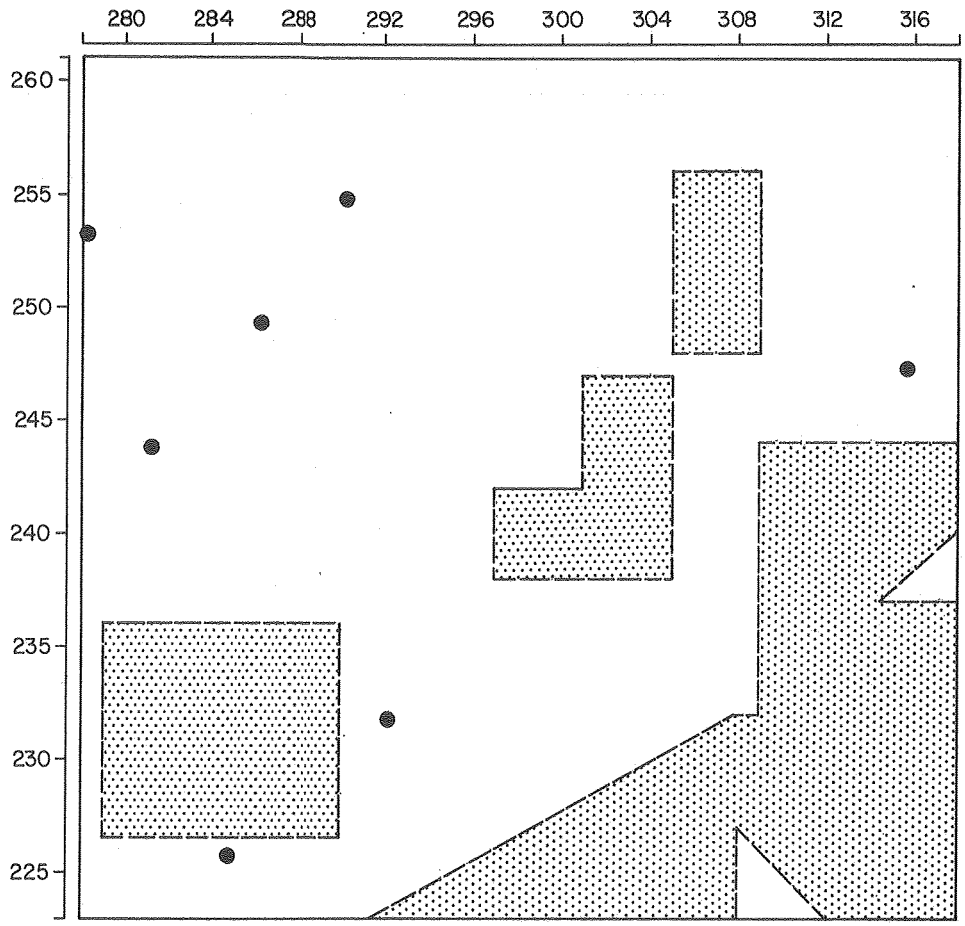


FIGURE 15 Block 23



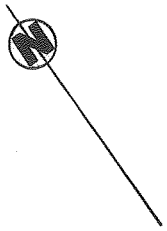
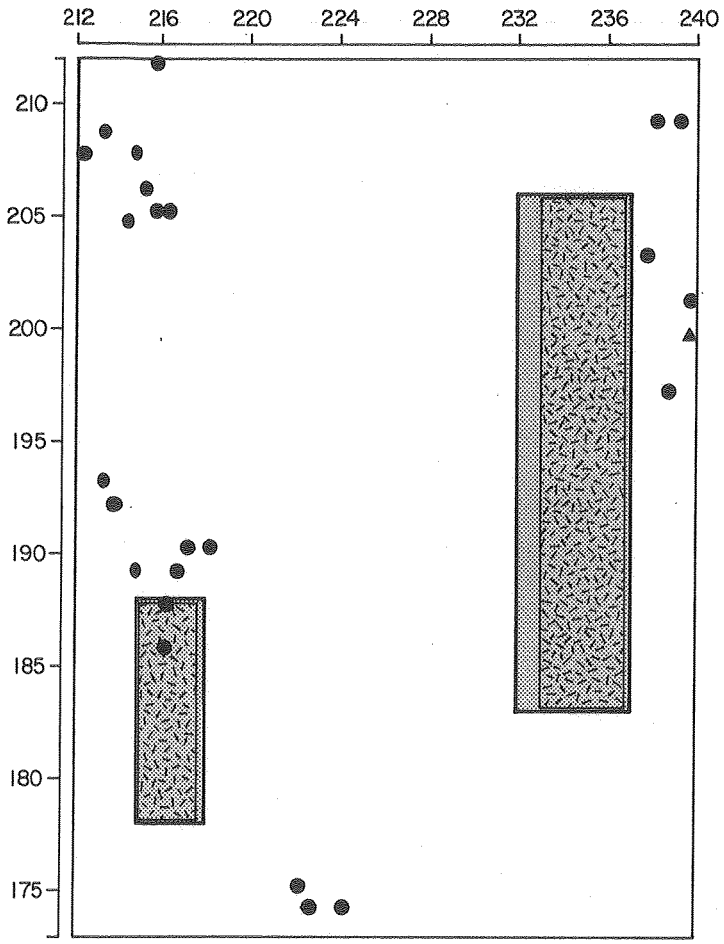


FIGURE 16 Block 23A



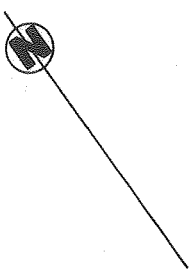


FIGURE 17 Block 24

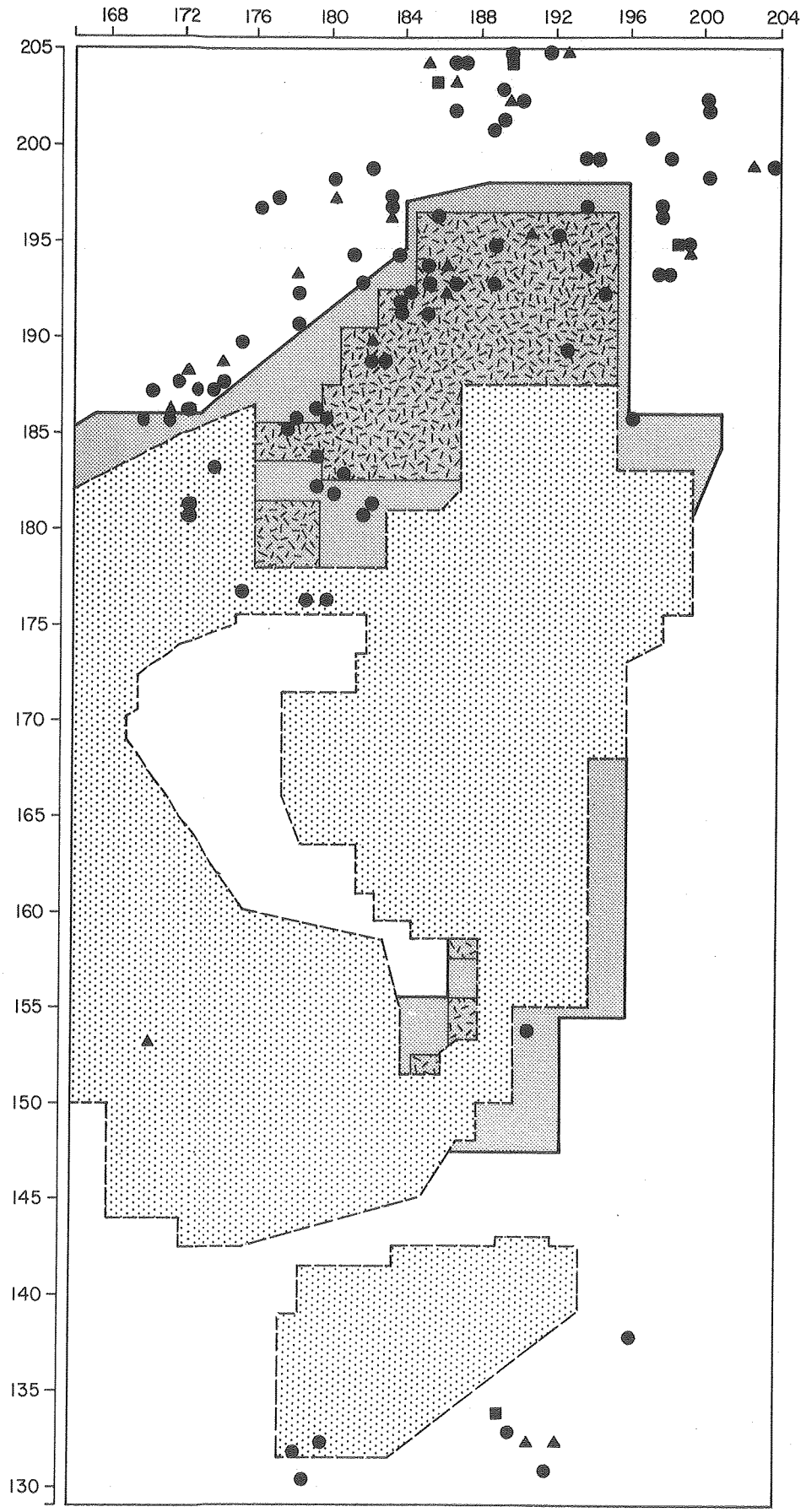


FIGURE 18 Block 25

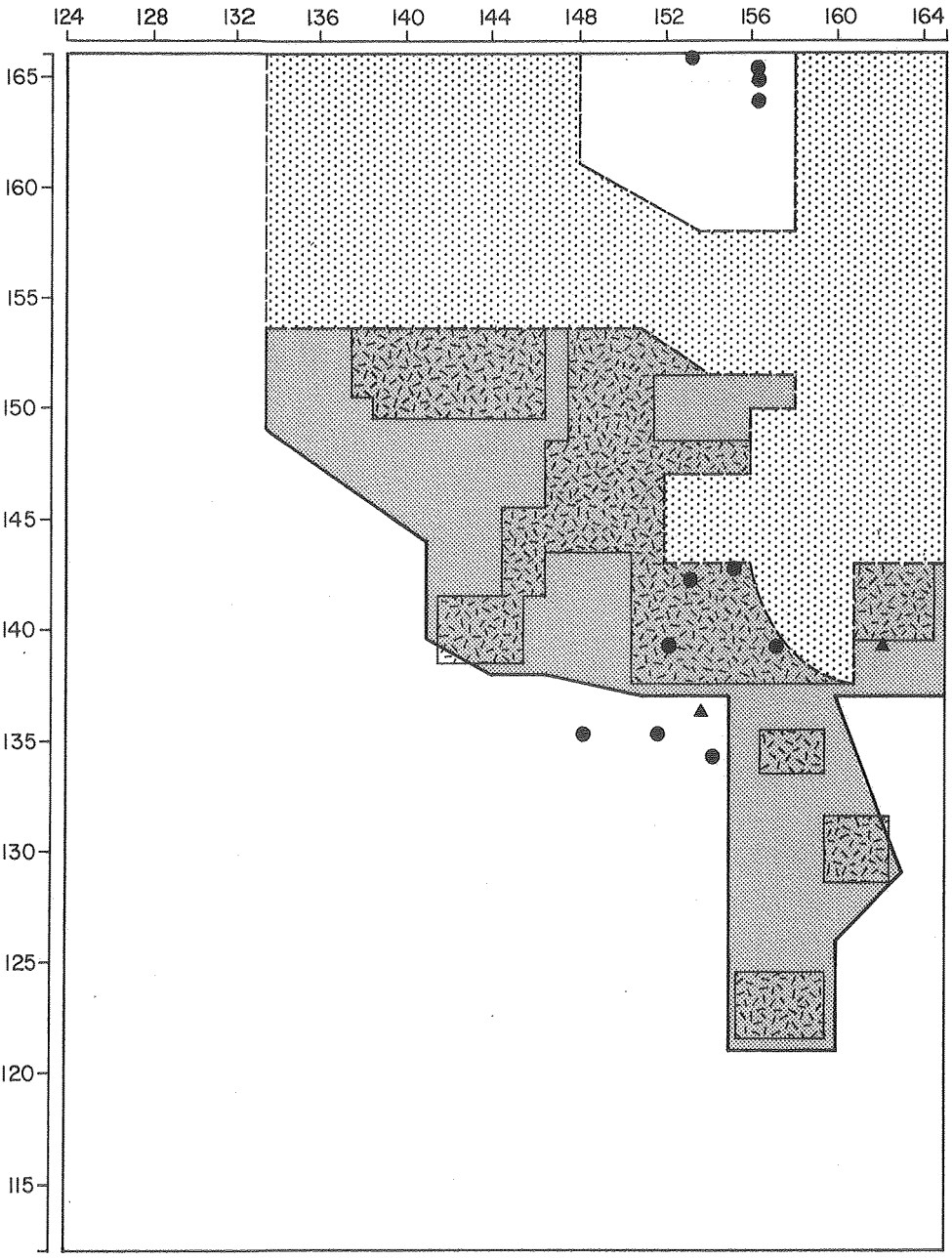


FIGURE 19 Block 26

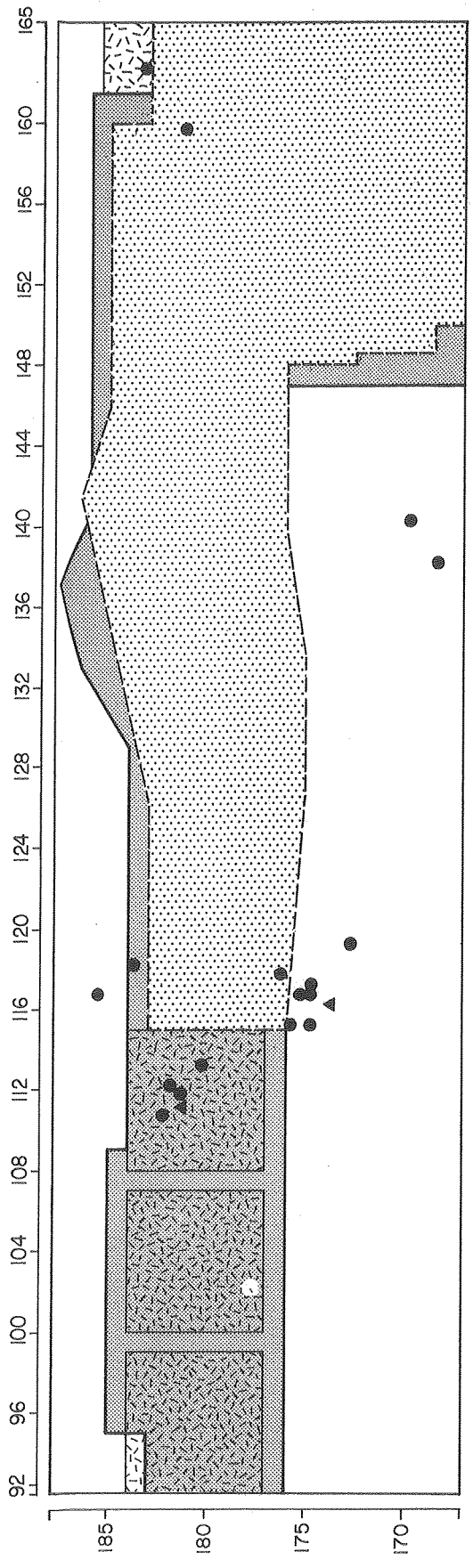


FIGURE 20 Block 27